Small Business Innovation Research/Small Business Tech Transfer

Planetary Volatiles Extractor for In-Situ Resource Utilization, Phase II

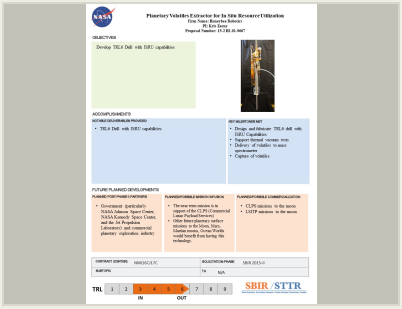
Completed Technology Project (2016 - 2019)

Project Introduction

In Situ Resource Utilization (ISRU) or ?living off the land relies on exploiting local resources and in turn reducing burden of transporting supplies. NASA has determined through various studies that ISRU will be critical for both robotic and human exploration of the Solar System. ISRU is also viewed by commercial Space companies as a significant source of revenue; volatiles (mainly water) could be mined and sold as Hydrogen/Oxygen fuel to satellite operators to extend spacecraft life. Traditional ISRU architecture follows methods employed in the mining industry on earth: material is mined, crushed, transported, crushed again, processed, and waste is disposed of. However, mining concrete-hard ice and icy-soil is difficult without using explosives. Volatiles will get lost during crushing and transportation, and robotic material handling, as shown by the 2008 Mars Phoenix mission, is difficult. For these reasons, we propose the Planetary Volatiles Extractor (PVEx) Corer, which uses a drill based excavation approach and an integrated volatiles extraction plant. PVEx successfully addresses several aspects: drills can penetrate hard materials, there is no need for material crushing and transfer, if volatiles sublime, they will flow directly into the capture system. PVEx can also work with hydrated minerals. Under the SBIR Phase 2 we propose to mature the technology from TRL 4 to TRL 5/6, and in turn ready the system for NASA's next HEOMD and SMD missions, as well as commercial planetary missions.

Anticipated Benefits

NASA applications would satisfy goals of HEOMD and SMD. In particular, the Planetary Volatiles Extractor could be initially used as a reconnaissance tool to map and characterize volatiles distribution around the area before deploying ISRU plants. Depending on the required water (or other volatiles) production levels per day, the PVEx could be used to extract water and other volatiles to support human habitats,for LOX/LH2 propulsion systems to enable return of humans or samples back to Earth or for a journey to the outer reaches of Space. Because of the system's flexibility, the PVEx could be deployed on any extraterrestrial body that contains volatiles or hydrated minerals: Mars, the Moon, Europa, Enceladus, Asteroids, Comets, Phobos and Deimos. If the system were to be deployed on the Moon or NEOs, the water produced by the system could be returned to the ISS. NASA's near term goal is to send humans to Mars. As such, PVEx could not only be used as a reconnaissance system, but also as a production plant to mine and process water and other volatiles. These would need to be mined and stored before human arrival to the surface.The PVEx system could be used by several commercial companies that are interested in In Situ Resource Utilization for financial gain. These include Planetary Resources and Deep Space Industries targeting Asteroids and Shackleton Energy Corp, targeting the Moon (see letter of interest from Shackleton Energy section 13). The ultimate goal of SpaceX is to establish human presence on Mars. As such, SpaceX would also benefit from mature



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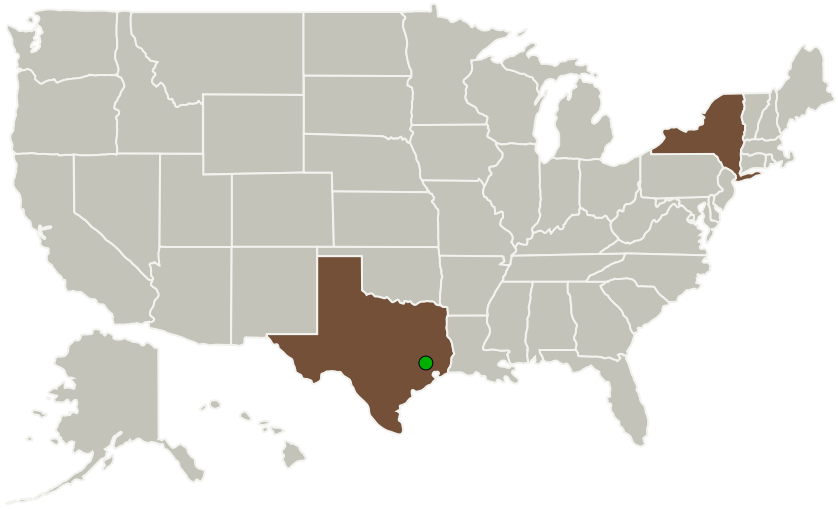
volatile extraction technology. Brining water from the Moon or NEOs could be very profitable given that launching water from Space costs ~$20,000/liter. The major market for water could be human consumption (e.g. once Bigelow Space Hotels are established) or refueling of existing satellites. The latter is of particular interest, since satellites come to the end of their life not because of electronics, or power, but because there are running out of fuel for station keeping. NASA and industry have been developing in space refueling technology, the first step in enabling refueling of satellites. Other non-NASA applications include robotic acquisition of volatiles as well as soil and liquid samples from hazardous environments: chemical spills, nuclear waste, oil spills.

Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
Honeybee Robotics, Ltd.	Lead Organization	Industry	Pasadena, California
Johnson Space Center(JSC)	Supporting Organization	NASA Center	Houston, Texas

Primary U.S. Work Locations	
New York	Texas

Organizational Responsibility

Responsible Mission Directorate:

Space Technology Mission Directorate (STMD)

Lead Organization:

Honeybee Robotics, Ltd.

Responsible Program:

Small Business Innovation Research/Small Business Tech Transfer

Project Management

Program Director:

Jason L Kessler

Program Manager:

Carlos Torrez

Project Managers:

Aaron Paz
Kathryn B Packard

Principal Investigator:

Kris Zacny

Co-Investigator:

Kris Zacny

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Project Transitions

April 2016: Project Start

December 2019: Closed out

Closeout Documentation:

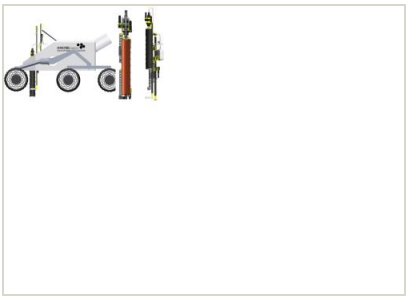
- Final Summary Chart*(https://techport.nasa.gov/file/139501)*

December 2019: Closed out

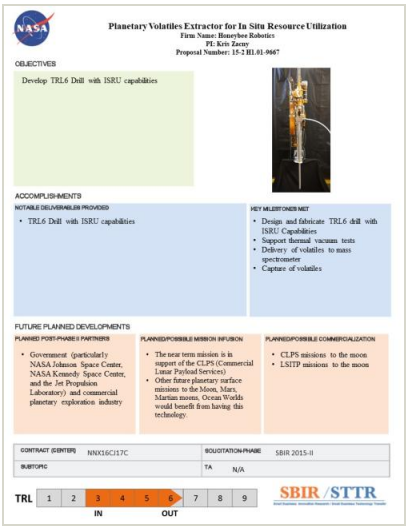
Closeout Documentation:

- Final Summary Chart PDF*(https://techport.nasa.gov/file/139500)*

Images



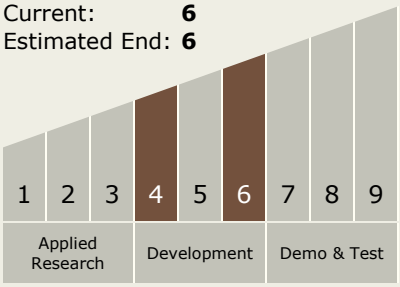
Briefing Chart Image
Planetary Volatiles Extractor for In Situ Resource Utilization, Phase II *(https://techport.nasa.gov/image/127608)*



Final Summary Chart Image
Planetary Volatiles Extractor for In-Situ Resource Utilization, Phase II *(https://techport.nasa.gov/image/128648)*

Technology Maturity (TRL)

Start: **4**
Current: **6**
Estimated End: **6**



Target Destinations

The Moon, Mars, Outside the Solar System, The Sun, Earth, Others Inside the Solar System